

**(57) Abstract:** The present invention presents an improved bellows shield for a plasma processing system, wherein the design and fabrication of the bellows shield coupled to a substrate holder electrode advantageously provides protection of a bellows with substantially minimal erosion of the bellows shield.



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## METHOD AND APPARATUS FOR AN IMPROVED BELLOWS SHIELD IN A PLASMA PROCESSING SYSTEM

### Cross-reference to Related Applications

[0001] This application is related to co-pending United States patent application serial no. 10/XXX,XXX, entitled "Method and apparatus for an improved upper electrode plate with deposition shield in a plasma processing system", Attorney docket no. 226272US6YA, filed on even date herewith; co-pending United States patent application serial no. 10/XXX,XXX, entitled "Method and apparatus for an improved baffle plate in a plasma processing system", Attorney docket no. 226274US6YA, filed on even date herewith; co-pending United States patent application serial no. 10/XXX,XXX, entitled "Method and apparatus for an improved baffle plate in a plasma processing system", Attorney docket no. 228411US6YA, filed on even date herewith; co-pending United States patent application serial no. 10/XXX,XXX, entitled "Method and apparatus for an improved deposition shield in a plasma processing system", Attorney docket no. 226275US6YA, filed on even date herewith; co-pending United States patent application serial no. 10/XXX,XXX, entitled "Method and apparatus for an improved optical window deposition shield in a plasma processing system", Attorney docket no. 226276US6YA, filed on even date herewith; and co-pending United States patent application serial no. 10/XXX,XXX, entitled "Method and apparatus for an improved upper electrode plate in a plasma processing system", Attorney docket no. 225277US6YA, filed on even date herewith. The entire contents of all of those applications are herein incorporated by reference in their entirety.

### Field of the Invention

[0002] The present invention relates to an improved component for a plasma processing system and, more particularly, to a bellows shield employed in a plasma processing system to protect a bellows.

### Background of the Invention

**[0003]** The fabrication of integrated circuits (IC) in the semiconductor industry typically employs plasma to create and assist surface chemistry within a plasma reactor necessary to remove material from and deposit material to a substrate. In general, plasma is formed within the plasma reactor under vacuum conditions by heating electrons to energies sufficient to sustain ionizing collisions with a supplied process gas. Moreover, the heated electrons can have energy sufficient to sustain dissociative collisions and, therefore, a specific set of gases under predetermined conditions (e.g., chamber pressure, gas flow rate, etc.) are chosen to produce a population of charged species and chemically reactive species suitable to the particular process being performed within the chamber (e.g., etching processes where materials are removed from the substrate or deposition processes where materials are added to the substrate).

**[0004]** Although the formation of a population of charged species (ions, etc.) and chemically reactive species is necessary for performing the function of the plasma processing system (i.e. material etch, material deposition, etc.) at the substrate surface, other component surfaces on the interior of the processing chamber are exposed to the physically and chemically active plasma and, in time, can erode. The erosion of exposed components in the plasma processing system can lead to a gradual degradation of the plasma processing performance and ultimately to complete failure of the system.

**[0005]** In order to minimize the damage sustained by exposure to the processing plasma, components of the plasma processing system, known to sustain exposure to the processing plasma, are coated with a protective barrier. For example, components fabricated from aluminum can be anodized to produce a surface layer of aluminum oxide, which is more resistant to the plasma. In another example, a consumable or replaceable component, such as one fabricated from silicon, quartz, alumina, carbon, or silicon carbide, can be inserted within the processing chamber to protect the surfaces of more valuable components that would impose greater costs during frequent replacement. Furthermore, it is desirable to select surface materials that minimize the introduction of unwanted contaminants, impurities, etc. to the processing plasma and possibly to the devices formed on the substrate.

**[0006]** In both cases, the inevitable failure of the protective coating, either due to the integrity of the protective barrier or the integrity of the fabrication of the protective barrier, and the consumable nature of the replaceable components demands frequent maintenance of the plasma processing system. This frequent maintenance can produce costs associated with plasma processing down-time and new plasma processing chamber components, which can be excessive.

#### Summary of the Invention

**[0007]** The present invention provides an improved bellows shield for a plasma processing system, wherein the design and fabrication of the bellows shield advantageously addresses the above-identified shortcomings.

**[0008]** It is an object of the present invention to provide a bellows shield that can be coupled to a substrate holder of the plasma processing system. The plasma processing system comprises a cylindrical wall having an inner surface, an outer surface, a first end, and a second end. The first end of the cylindrical wall can comprise an attachment flange, wherein the attachment flange comprises an interior surface coupled to the inner surface of the cylindrical wall and configured to mate with the substrate holder, an inner radial surface, and an exterior surface coupled to the outer surface of the cylindrical wall. The second end of the cylindrical wall can comprise an end surface.

**[0009]** The attachment flange of the bellows shield can further include a plurality of fastening receptors for receiving fastening devices in order to attach the bellows shield to the substrate holder. Each fastening receptor can comprise an entrant cavity, an exit through-hole, and an inner receptor surface.

**[0010]** The bellows shield can further comprise a protective barrier formed on a plurality of exposed surfaces of the bellows shield facing the processing plasma.

**[0011]** It is a further object of the present invention that the plurality of exposed surfaces of the bellows shield comprises the end surface of the cylindrical wall, the outer surface of the cylindrical wall, and the exterior surface of the attachment flange contiguous with the outer surface of the cylindrical wall.

**[0012]** The present invention provides a method of producing a bellows shield in the plasma processing system comprising the steps: fabricating the bellows shield; anodizing the bellows shield to form a surface anodization layer on the bellows

shield; machining the exposed surfaces on the bellows shield to remove the surface anodization layer; and forming a protective barrier on the exposed surfaces.

**[0013]** The present invention may optionally include machining of other parts not actually exposed to the plasma. Such parts may be machined in order to provide a contact free from the anodization layer (e.g., in order to provide a better mechanical or electrical contact). Such parts may include, but are not limited to, an interior surface of the attachment flange and an inner receptor surface of the plurality of fastening receptors.

**[0014]** The present invention provides another method of producing the bellows shield in the plasma processing system comprising the steps: fabricating the bellows shield; masking the exposed surfaces on the bellows shield to prevent formation of a surface anodization layer; anodizing the bellows shield to form the surface anodization layer on the bellows shield; and forming a protective barrier on the exposed surfaces.

**[0015]** The present invention may optionally include masking of other parts not actually exposed to the plasma. Such parts may be masked in order to provide a contact free from the anodization layer (e.g., in order to provide a better mechanical or electrical contact). Such parts may include, but are not limited to, an interior surface of the attachment flange and an inner receptor surface of the plurality of fastening receptors.

**[0016]** The present invention also provides a combined method of machining and masking to provide bare exposed surfaces on which to form the protective barrier.

#### Brief Description of the Drawings

**[0017]** These and other advantages of the invention will become more apparent and more readily appreciated from the following detailed description of the exemplary embodiments of the invention taken in conjunction with the accompanying drawings, where:

**[0018]** FIG. 1 shows a simplified block diagram of a plasma processing system comprising a bellows shield according to an embodiment of the present invention;

**[0019]** FIG. 2 shows a cross-sectional view of a bellows shield for a plasma processing system according to an embodiment of the present invention;

- [0020] FIG. 3 shows a partial plan view of a bellows shield for the plasma processing system according to an embodiment of the present invention;
- [0021] FIG. 4 shows an exploded view of an attachment flange of the bellows shield for the plasma processing system according to an embodiment of the present invention;
- [0022] FIG. 5 shows an exploded view of an end surface on a second end of the bellows shield for the plasma processing system according to an embodiment of the present invention;
- [0023] FIG. 6 presents a method of producing a bellows shield for the plasma processing system according to an embodiment of the present invention;
- [0024] FIG. 7 presents a method of producing a bellows shield for the plasma processing system according to another embodiment of the present invention; and
- [0025] FIG. 8 presents a method of producing a bellows shield for the plasma processing system according to another embodiment of the present invention.

#### Detailed Description of an Embodiment

[0026] According to an embodiment of the present invention, a plasma processing system 1 is depicted in FIG. 1 comprising a plasma processing chamber 10, an upper assembly 20, an electrode plate 24, a substrate holder 30 for supporting a substrate 35, and a pumping duct 40 coupled to a vacuum pump (not shown) for providing a reduced pressure atmosphere 11 in plasma processing chamber 10. Plasma processing chamber 10 can facilitate the formation of a processing plasma in a process space 12 adjacent substrate 35. The plasma processing system 1 can be configured to process substrates of various sizes (e.g., 200 mm substrates, 300 mm substrates, or larger).

[0027] In the illustrated embodiment, upper assembly 20 can comprise at least one of a cover, a gas injection assembly, and an upper electrode impedance match network. For example, the electrode plate 24 can be coupled to an RF source. In another alternate embodiment, the upper assembly 20 comprises a cover and an electrode plate 24, wherein the electrode plate 24 is maintained at an electrical potential equivalent to that of the plasma processing chamber 10. For example, the plasma processing chamber 10, the upper assembly 20, and the electrode plate 24 can be electrically connected to ground potential.

**[0028]** Plasma processing chamber 10 can, for example, further comprise a deposition shield 14 for protecting the plasma processing chamber 10 from the processing plasma in the process space 12, and an optical viewport 16. Optical viewport 16 can comprise an optical window 17 coupled to the backside of an optical window deposition shield 18, and an optical window flange 19 can be configured to couple optical window 17 to the optical window deposition shield 18. Sealing members, such as O-rings, can be provided between the optical window flange 19 and the optical window 17, between the optical window 17 and the optical window deposition shield 18, and between the optical window deposition shield 18 and the plasma processing chamber 10. Optical viewport 16 can, for example, permit monitoring of optical emission from the processing plasma in process space 12.

**[0029]** Substrate holder 30 can, for example, further comprise a vertical translational device 50 surrounded by a bellows 52 coupled to the substrate holder 30 and the plasma processing chamber 10, and configured to seal the vertical translational device 50 from the reduced pressure atmosphere 11 in plasma processing chamber 10. Additionally, a bellows shield 54 can, for example, be coupled to the substrate holder 30 and configured to protect the bellows 52 from the processing plasma. Substrate holder 10 can, for example, further be coupled to at least one of a focus ring 60, and a shield ring 62. Furthermore, a baffle plate 64 can extend about a periphery of the substrate holder 30.

**[0030]** Substrate 35 can be, for example, transferred into and out of plasma processing chamber 10 through a slot valve (not shown) and chamber feed-through (not shown) via robotic substrate transfer system where it is received by substrate lift pins (not shown) housed within substrate holder 30 and mechanically translated by devices housed therein. Once substrate 35 is received from substrate transfer system, it is lowered to an upper surface of substrate holder 30.

**[0031]** Substrate 35 can be, for example, affixed to the substrate holder 30 via an electrostatic clamping system. Furthermore, substrate holder 30 can, for example, further include a cooling system including a re-circulating coolant flow that receives heat from substrate holder 30 and transfers heat to a heat exchanger system (not shown), or when heating, transfers heat from the heat exchanger system. Moreover, gas can, for example, be delivered to the back-side of substrate 35 via a backside gas system to improve the gas-gap thermal conductance between substrate 35 and substrate holder 30. Such a system can be utilized when temperature control of the



substrate is required at elevated or reduced temperatures. In other embodiments, heating elements, such as resistive heating elements, or thermo-electric heaters/coolers can be included.

**[0032]** In the illustrated embodiment, shown in FIG. 1, substrate holder 30 can comprise an electrode through which RF power is coupled to the processing plasma in process space 12. For example, substrate holder 30 can be electrically biased at a RF voltage via the transmission of RF power from a RF generator (not shown) through an impedance match network (not shown) to substrate holder 30. The RF bias can serve to heat electrons to form and maintain plasma. In this configuration, the system can operate as a reactive ion etch (RIE) reactor, wherein the chamber and upper gas injection electrode serve as ground surfaces. A typical frequency for the RF bias can range from 1 MHz to 100 MHz and is preferably 13.56 MHz. RF systems for plasma processing are well known to those skilled in the art.

**[0033]** Alternately, the processing plasma formed in process space 12 can be formed using a parallel-plate, capacitively coupled plasma (CCP) source, an inductively coupled plasma (ICP) source, any combination thereof, and with and without DC magnet systems. Alternately, the processing plasma in process space 12 can be formed using electron cyclotron resonance (ECR). In yet another embodiment, the processing plasma in process space 12 is formed from the launching of a Helicon wave. In yet another embodiment, the processing plasma in process space 12 is formed from a propagating surface wave.

**[0034]** Referring now to an illustrated embodiment of the present invention depicted in FIG. 2 (cross-sectional view) and FIG. 3 (partial plan view), bellows shield 54 comprises a cylindrical wall 80, the cylindrical wall 80 comprising an inner surface 82, an outer surface 84, a first end 86, and a second end 88. The first end 86 of cylindrical wall 80 comprises an attachment flange 90 coupled to the cylindrical wall 80 and configured to attach the bellows shield 54 to the substrate holder 30, and a through-hole 92 to accommodate an upper surface of the substrate holder 30. The second end 88 of the cylindrical wall 80 comprises an end surface 94.

**[0035]** FIG. 4 provides an expanded view of the attachment flange 90 coupled to cylindrical wall 80 and configured to couple the bellows shield 54 to the substrate holder 30. The attachment flange 90 comprises an interior surface 96, an inner radial surface 97, and an exterior surface 98. Additionally, the interior surface 96 can comprise a mating surface 99 and the exterior surface can comprise a mounting

surface 91 that are configured to couple the bellows shield 54 to the substrate holder 30.

**[0036]** Furthermore, attachment flange 90 can, for example, comprise a plurality of fastening receptors 100, each fastening receptor 100 coupled to the interior surface 96 and the exterior surface 98, and configured to receive fastening devices (not shown) (such as bolts) to couple bellows shield 54 to substrate holder 30. The fastening receptors 100 can comprise an entrant cavity 102, an exit through-hole 104, and an inner receptor surface 106. For example, the number of fastening receptors 100 formed within bellows shield 54 can range from 0 to 100. Desirably, the number of fastening receptors 100 can range from 5 to 20; and, preferably, the number of fastening receptors 100 is at least 6.

**[0037]** FIG. 5 provides an expanded view of the end surface 94 forming the second end 88 of the cylindrical wall 80.

**[0038]** Referring now to FIGs. 2 through 5, the bellows shield 54 further comprises a protective barrier 150 formed on a plurality of exposed surfaces 110 of the bellows shield 54. In an embodiment of the present invention, the plurality of exposed surfaces 110 can comprise the end surface 94 of the cylindrical wall 80, the outer surface 84 of the cylindrical wall 80, and the exterior surface 98 of the attachment flange 90 contiguous with the outer surface 84 of the cylindrical wall 80. Alternately, the exposed surfaces 110 can further comprise all of the surfaces remaining on the bellows shield 54.

**[0039]** In an embodiment of the present invention, the protective barrier 150 can comprise a compound including an oxide of aluminum such as  $\text{Al}_2\text{O}_3$ . In another embodiment of the present invention, the protective barrier 150 can comprise a mixture of  $\text{Al}_2\text{O}_3$  and  $\text{Y}_2\text{O}_3$ . In another embodiment of the present invention, the protective barrier 150 can comprise at least one of a III-column element (column III of periodic table) and a Lanthanoid element. In another embodiment of the present invention, the III-column element can comprise at least one of Yttrium, Scandium, and Lanthanum. In another embodiment of the present invention, the Lanthanoid element can comprise at least one of Cerium, Dysprosium, and Europium. In another embodiment of the present invention, the compound forming protective barrier 150 can comprise at least one of Ytria ( $\text{Y}_2\text{O}_3$ ),  $\text{Sc}_2\text{O}_3$ ,  $\text{Sc}_2\text{F}_3$ ,  $\text{YF}_3$ ,  $\text{La}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{Eu}_2\text{O}_3$ , and  $\text{DyO}_3$ .

**[0040]** In an embodiment of the present invention, the protective barrier 150 formed on bellows shield 54 comprises a minimum thickness, wherein the minimum thickness can be specified as constant across at least one of the plurality of exposed surfaces 110. In another embodiment, the minimum thickness can be variable across at least one of the plurality of exposed surfaces 110. Alternately, the minimum thickness can be constant over a first portion of at least one of the plurality of exposed surfaces 110 and variable over a second portion of at least one of the plurality of exposed surfaces 110 (i.e., a variable thickness can occur on a curved surface, on a corner, or in a hole). For example, the minimum thickness can range from 0.5 micron to 500 micron. Desirably, the minimum thickness ranges from 100 micron to 200 micron; and, preferably, the minimum thickness is at least 20 micron.

**[0041]** FIG. 6 presents a method of producing the bellows shield in the plasma processing system described in FIG. 1 according to an embodiment of the present invention. A flow diagram 300 begins in 310 with fabricating the bellows shield 54 (as described above). Fabricating the bellows shield can comprise at least one of machining, casting, polishing, forging, and grinding. For example, each of the elements described above can be machined according to specifications set forth on a mechanical drawing, using conventional techniques including a mill, a lathe, etc. The techniques for machining a component using, for example, a mill or a lathe, are well known to those skilled in the art of machining. The bellows shield 54 can, for example, be fabricated from aluminum.

**[0042]** In 320, the bellows shield is anodized to form a surface anodization layer. For example, when fabricating the bellows shield from aluminum, the surface anodization layer comprises aluminum oxide ( $\text{Al}_2\text{O}_3$ ). Methods of anodizing aluminum components are well known to those skilled in the art of surface anodization.

**[0043]** In 330, the surface anodization layer is removed from the exposed surfaces 110 using standard machining techniques. In this step, or in a separate step, additional non-exposed surfaces (e.g., a mating surface of an interior surface of the attachment flange and an inner receptor surface of the plurality of fastening receptors) may also be machined. Such non-exposed surfaces may be machined in order to provide better mechanical or electrical contacts between those parts and the parts with which they are mated.

**[0044]** In 340, the protective barrier 150 is formed on the exposed surfaces 110. A protective barrier comprising, for example Yttria, can be formed using (thermal) spray coating techniques that are well known to those skilled in the art of ceramic spray coatings. In an alternate embodiment, forming the protective barrier can further comprise polishing (or smoothing) the thermal spray coating. For example, polishing the thermal spray coating can comprise the application of sand paper to the sprayed surfaces.

**[0045]** FIG. 7 presents a method of producing the bellows shield in the plasma processing system described in FIG. 1 according to another embodiment of the present invention. A flow diagram 400 begins in 410 with fabricating the bellows shield 54 (as described above). Fabricating the bellows shield can comprise at least one of machining, casting, polishing, forging, and grinding. For example, each of the elements described above can be machined according to specifications set forth on a mechanical drawing, using conventional techniques including a mill, a lathe, etc. The techniques for machining a component using, for example, a mill or a lathe, are well known to those skilled in the art of machining. The bellows shield 54 can, for example, be fabricated from aluminum.

**[0046]** In 420, the exposed surfaces 110 are masked to prevent the formation of a surface anodization layer thereon. In this step, or in a separate step, additional non-exposed surfaces (e.g., an interior surface of the attachment flange and an inner receptor surface of the plurality of fastening receptors) may be masked. Such non-exposed surfaces may be masked in order to provide better mechanical or electrical contacts between those parts and the parts with which they are mated. Techniques for surface masking and unmasking are well known to those skilled in the art of surface coatings and surface anodization.

**[0047]** In 430, the bellows shield is anodized to form a surface anodization layer on the remaining unmasked surfaces. For example, when fabricating the bellows shield from aluminum, the surface anodization layer can comprise aluminum oxide ( $\text{Al}_2\text{O}_3$ ). Methods of anodizing aluminum components are well known to those skilled in the art of surface anodization.

**[0048]** In 440, the protective barrier 150 is formed on the exposed surfaces 110. A protective barrier comprising, for example Yttria, can be formed using (thermal) spray coating techniques that are well known to those skilled in the art of ceramic spray coatings. In an alternate embodiment, forming the protective barrier can

further comprise polishing (or smoothing) the thermal spray coating. For example, polishing the thermal spray coating can comprise the application of sand paper to the sprayed surfaces.

**[0049]** FIG. 8 presents a method of producing the electrode plate in the plasma processing system described in FIG. 1 according to another embodiment of the present invention. A flow diagram 500 begins in 510 with fabricating the bellows shield 54 (as described above). Fabricating the electrode plate can comprise at least one of machining, casting, polishing, forging, and grinding. For example, each of the elements described above can be machined according to specifications set forth on a mechanical drawing, using conventional techniques including a mill, a lathe, etc. The techniques for machining a component using, for example, a mill or a lathe, are well known to those skilled in the art of machining. The electrode plate can, for example, be fabricated from aluminum.

**[0050]** In 520, a protective barrier is formed on the exposed surfaces 110 of the electrode plate. A protective barrier comprising, for example Yttria, can be formed using (thermal) spray coating techniques that are well known to those skilled in the art of ceramic spray coatings. In an alternate embodiment, forming the protective barrier can further comprise polishing (or smoothing) the thermal spray coating. For example, polishing the thermal spray coating can comprise the application of sand paper to the sprayed surfaces.

**[0051]** The processes of forming a protective barrier 150 on the exposed surfaces 110, described with reference to FIGs. 6-8 can be modified to utilize a combination of machining and masking. In such a modified process, at least one exposed surface 110 is masked to prevent formation of the anodization layer thereon while other exposed surfaces 110 are anodized. The exposed surfaces 110 that are unmasked are then machined, and the exposed surfaces that were masked are unmasked. The protective barrier 150 can then be formed on all the exposed surfaces 110. As described above, additional surfaces that are not exposed surfaces may also be machined during the method (e.g., in order to provide a better mechanical or electrical contact than we be formed with the anodization layer thereon.

**[0052]** Although only certain exemplary embodiments of this invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially

departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention.

**CLAIMS:**

What is claimed is:

1. An improved bellows shield for protecting a bellows on a substrate holder of a plasma processing system comprising:

a cylindrical wall comprising an inner surface, an outer surface, a first end, and a second end, wherein said first end comprises an attachment flange, said attachment flange comprising an interior surface coupled to said inner surface of said cylindrical wall and configured to mate with said substrate holder, an inner radial surface coupled to said interior surface, and an exterior surface coupled to said outer surface and said inner radial surface, and wherein said second end of said cylindrical wall comprises an end surface; and

a protective barrier coupled to a plurality of exposed surfaces of said bellows shield, wherein said plurality of exposed surfaces comprise said end surface of said second end, said outer surface of said cylindrical wall, and said exterior surface of said attachment flange of said first end.

2. The improved bellows shield as recited in claim 1, wherein said attachment flange further comprises a plurality of fastening receptors coupled to said interior surface and said exterior surface of said attachment flange and configured to receive fastening devices in order to couple said bellows shield to said substrate holder.

3. The improved bellows shield as recited in claim 2, wherein each of said plurality of fastening receptors comprises an entrant cavity, an exit through-hole, and an inner receptor surface.

4. The improved bellows shield as recited in claim 1, wherein said improved bellows shield comprises a metal.

5. The improved bellows shield as recited in claim 4, wherein said metal comprises aluminum.

6. The improved bellows shield as recited in claim 1, wherein said protective barrier comprises a compound containing at least one of a III-column element and a Lanthanoid element.

7. The improved bellows shield as recited in claim 6, wherein said III-column element comprises at least one of Yttrium, Scandium, and Lanthanum.

8. The improved bellows shield as recited in claim 6, wherein said Lanthanoid element comprises at least one of Cerium, Dysprosium, and Europium.

9. The improved bellows shield as recited in claim 1, wherein said protective barrier comprises at least one of  $Y_2O_3$ ,  $Sc_2O_3$ ,  $Sc_2F_3$ ,  $YF_3$ ,  $La_2O_3$ ,  $CeO_2$ ,  $Eu_2O_3$ , and  $DyO_3$ .

10. The improved bellows shield as recited in claim 1, wherein said protective barrier comprises a thermal spray coating having a minimum thickness and said minimum thickness is constant across at least one of said exposed surfaces.

11. The improved bellows shield as recited in claim 1, wherein said protective barrier comprises a thermal spray coating having a minimum thickness and said minimum thickness is variable across at least one of said exposed surfaces.

12. The improved bellows shield as recited in claim 1, wherein said cylindrical wall has a minimum thickness of at least two millimeters.

13. The improved bellows shield as recited in claim 1, wherein said inner radial surface comprises a minimum diameter of at least 200 millimeters.

14. A bellows shield for protecting a bellows on a substrate holder of a plasma processing system comprising:

a cylindrical element comprising an inner surface, an outer surface, an interior surface coupled to said inner surface and configured to mate with said substrate holder, an inner radial surface coupled to said interior surface, and an exterior



surface coupled to said outer surface and said inner radial surface, and an end surface coupled to said inner surface and said outer surface; and

a protective barrier coupled to a plurality of exposed surfaces of said bellows shield, wherein said plurality of exposed surfaces comprise said end surface, said outer surface, and said exterior surface.

15. The bellows shield as recited in claim 14, further comprising a plurality of fastening receptors coupled to said interior surface and said exterior surface and configured to receive fastening devices in order to couple said bellows shield to said substrate holder.

16. The bellows shield as recited in claim 15, wherein each of said plurality of fastening receptors comprises an entrant cavity, an exit through-hole, and an inner receptor surface.

17. The bellows shield as recited in claim 14, said interior surface further comprising a mating surface.

18. The bellows shield as recited in claim 17, further comprising a plurality of fastening receptors coupled to said mating surface and said exterior surface and configured to receive fastening devices in order to couple said bellows shield to said substrate holder.

19. The bellows shield as recited in claim 14, said exterior surface further comprising a mounting surface.

20. The bellows shield as recited in claim 19, further comprising a plurality of fastening receptors coupled to said mounting surface and said interior surface and configured to receive fastening devices in order to couple said bellows shield to said substrate holder.

21. The bellows shield as recited in claim 14, further comprising a metal.

22. The bellows shield as recited in claim 21, wherein said metal comprises aluminum.

23. The bellows shield as recited in claim 14, wherein said inner radial surface comprises a diameter greater than 200 mm.

24. The bellows shield as recited in claim 14, wherein said protective barrier comprises a compound containing at least one of a III-column element and a Lanthanon element.

25. The bellows shield as recited in claim 24, wherein said III-column element comprises at least one of Yttrium, Scandium, and Lanthanum.

26. The bellows shield as recited in claim 24, wherein said Lanthanon element comprises at least one of Cerium, Dysprosium, and Europium.

27. The bellows shield as recited in claim 14, wherein said protective barrier comprises at least one of  $Y_2O_3$ ,  $Sc_2O_3$ ,  $Sc_2F_3$ ,  $YF_3$ ,  $La_2O_3$ ,  $CeO_2$ ,  $Eu_2O_3$ , and  $DyO_3$ .

28. The bellows shield as recited in claim 14, said inner surface further comprising an anodization layer.

29. The bellows shield as recited in claim 28, wherein said anodization layer comprises  $Al_2O_3$ .

30. The bellows shield as recited in claim 14, said interior surface further comprising an anodization layer.

31. A method of producing a bellows shield for surrounding a bellows in a plasma processing system, said method comprising:

fabricating said bellows shield, said bellows shield comprising a cylindrical element having an inner surface, an outer surface, an interior surface coupled to said inner surface and configured to mate with a substrate holder in said plasma processing system, an inner radial surface coupled to said interior surface, and an

exterior surface coupled to said outer surface and said inner radial surface, and an end surface coupled to said inner surface and said outer surface; and

forming a protective barrier on exposed surfaces, said exposed surfaces comprising said end surface, said outer surface, and said exterior surface.

32. The method as recited in claim 31, said method further comprising:  
anodizing said bellows shield to form a surface anodization layer on said bellows shield; and

removing said surface anodization layer on said exposed surfaces.

33. The method as recited in claim 32, wherein said removing comprises at least one of machining, smoothing, polishing, and grinding.

34. The method as recited in claim 31, said method further comprising:  
masking said exposed surfaces on said bellows shield to prevent formation of a surface anodization layer;

anodizing said bellows shield to form a surface anodization layer on the unmasked surfaces of said bellows shield; and

unmasking said exposed surfaces.

35. The method as recited in claim 31, wherein said fabricating comprises at least one of machining, coating, masking, unmasking, casting, polishing, forging, and grinding.

36. The method as recited in claim 31, wherein said forming comprises at least one of spraying, heating, and cooling.

37. The method as recited in claim 31, said method further comprising smoothing said protective barrier.

38. The method as recited in claim 31, wherein said bellows shield further comprises a plurality of fastening receptors coupled to said interior surface and said

exterior surface and configured to receive fastening devices in order to couple said bellows shield to said substrate holder.

39. The method as recited in claim 38, wherein each of said plurality of fastening receptors comprises an entrant cavity, an exit through-hole, and an inner receptor surface.

40. The method as recited in claim 31, said interior surface further comprising a mating surface.

41. The method as recited in claim 31, said exterior surface further comprising a mounting surface.

42. The method as recited in claim 31, said bellows shield comprising a metal.

43. The method as recited in claim 42, wherein said metal comprises aluminum.

44. The method as recited in claim 31, wherein said exposed surfaces further comprise said inner radial surface.

45. The method as recited in claim 31, wherein said protective barrier comprises a compound containing at least one of a III-column element and a Lanthanum element.

46. The method as recited in claim 45, wherein said III-column element comprises at least one of Yttrium, Scandium, and Lanthanum.

47. The method as recited in claim 45, wherein said Lanthanum element comprises at least one of Cerium, Dysprosium, and Europium.

48. The method as recited in claim 31, wherein said protective barrier comprises at least one of  $Y_2O_3$ ,  $Sc_2O_3$ ,  $Sc_2F_3$ ,  $YF_3$ ,  $La_2O_3$ ,  $CeO_2$ ,  $Eu_2O_3$ , and  $DyO_3$ .

49. The method as recited in claim 31, wherein said protective barrier comprises a minimum thickness and said minimum thickness is constant across at least one of said exposed surfaces.

50. The method as recited in claim 31, wherein said protective barrier comprises a variable thickness and said variable thickness ranging from 0.5 to 500 microns.

51. A method of producing an improved bellows shield capable of being coupled to a substrate holder of a plasma processing system, said method comprising the steps:

fabricating said bellows shield, said bellows shield comprising a cylindrical wall comprising an inner surface, an outer surface, a first end, and a second end, wherein said first end comprises an attachment flange, said attachment flange comprising an interior surface coupled to said inner surface of said cylindrical wall and configured to mate with said substrate holder, an inner radial surface coupled to said interior surface, and an exterior surface coupled to said outer surface of said cylindrical wall and said inner radial surface, and wherein said second end of said cylindrical wall comprising an end surface;

anodizing said bellows shield to form a surface anodization layer on said bellows shield;

machining exposed surfaces on said bellows shield to remove said surface anodization layer, said exposed surfaces comprising said end surface of said cylindrical wall, said outer surface of said cylindrical wall, and said exterior surface of said attachment flange; and

forming a protective barrier on the exposed surfaces.

52. The method as recited in claim 51, wherein said attachment flange further comprises a plurality of fastening receptors coupled to said interior surface and said exterior surface of said attachment flange and configured to receive fastening devices in order to couple said bellows shield to said substrate holder.

53. The method as recited in claim 51, wherein said protective barrier comprises a compound containing at least one of a III-column element and a Lanthanum element.

54. The method as recited in claim 51, wherein said protective barrier comprises at least one of  $Y_2O_3$ ,  $Sc_2O_3$ ,  $Sc_2F_3$ ,  $YF_3$ ,  $La_2O_3$ ,  $CeO_2$ ,  $Eu_2O_3$ , and  $DyO_3$ .

55. A method of producing an improved bellows shield capable of being coupled to a substrate holder of a plasma processing system, said method comprising the steps:

fabricating said bellows shield, said bellows shield comprising a cylindrical wall comprising an inner surface, an outer surface, a first end, and a second end, wherein said first end of said cylindrical wall comprises an attachment flange, said attachment flange comprising an interior surface coupled to said inner surface of said cylindrical wall and configured to mate with said substrate holder, an inner radial surface, and an exterior surface coupled to said outer surface of said cylindrical wall, and wherein said second end of said cylindrical wall comprising an end surface;

masking exposed surfaces on said bellows shield to prevent formation of a surface anodization layer, said exposed surfaces comprising said end surface of said cylindrical wall, said outer surface of said cylindrical wall, and said exterior surface of said attachment flange coupled to said cylindrical wall;

anodizing said bellows shield to form said surface anodization layer on said bellows shield;

unmasking the exposed surfaces; and

forming a protective barrier on the exposed surfaces.

56. The method as recited in claim 55, wherein said attachment flange further comprises a plurality of fastening receptors coupled to said interior surface and said exterior surface of said attachment flange and configured to receive fastening devices in order to couple said bellows shield to said substrate holder.

57. The method as recited in claim 56, wherein each of said plurality of fastening receptors comprises an entrant cavity, an exit through-hole, and an inner receptor surface.

58. The method as recited in claim 57, further comprising masking said inner receptor surface.

59. The method as recited in claim 55, wherein said protective barrier comprises a compound containing at least one of a III-column element and a Lanthanum element.

60. The method as recited in claim 55, wherein said protective barrier comprises at least one of  $Y_2O_3$ ,  $Sc_2O_3$ ,  $Sc_2F_3$ ,  $YF_3$ ,  $La_2O_3$ ,  $CeO_2$ ,  $Eu_2O_3$ , and  $DyO_3$ .

61. A method of producing an improved bellows shield capable of being coupled to a substrate holder of a plasma processing system, said method comprising the steps:

fabricating said bellows shield, said bellows shield comprising a cylindrical wall comprising an inner surface, an outer surface, a first end, and a second end, wherein said first end of said cylindrical wall comprises an attachment flange, said attachment flange comprising an interior surface coupled to said inner surface of said cylindrical wall, said interior surface having a mating surface configured to mate with said substrate holder, an inner radial surface, and an exterior surface coupled to said outer surface of said cylindrical wall, and wherein said second end of said cylindrical wall can comprise an end surface;

masking exposed surfaces on said bellows shield to prevent formation of a surface anodization layer, said exposed surfaces comprising said end surface of said cylindrical wall, said outer surface of said cylindrical wall, and said exterior surface of said attachment flange coupled to said cylindrical wall;

anodizing said bellows shield to form said surface anodization layer on said bellows shield;

unmasking said exposed surfaces;

machining said mating surface of said interior surface of said attachment flange; and

forming a protective barrier on the exposed surfaces.

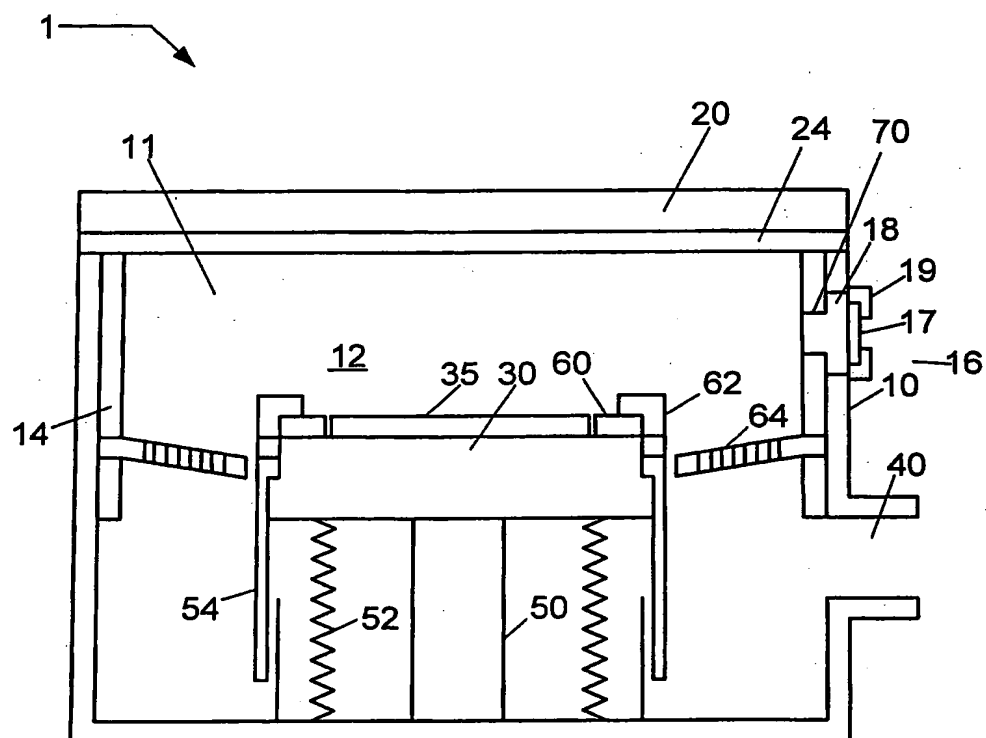


FIG. 1.



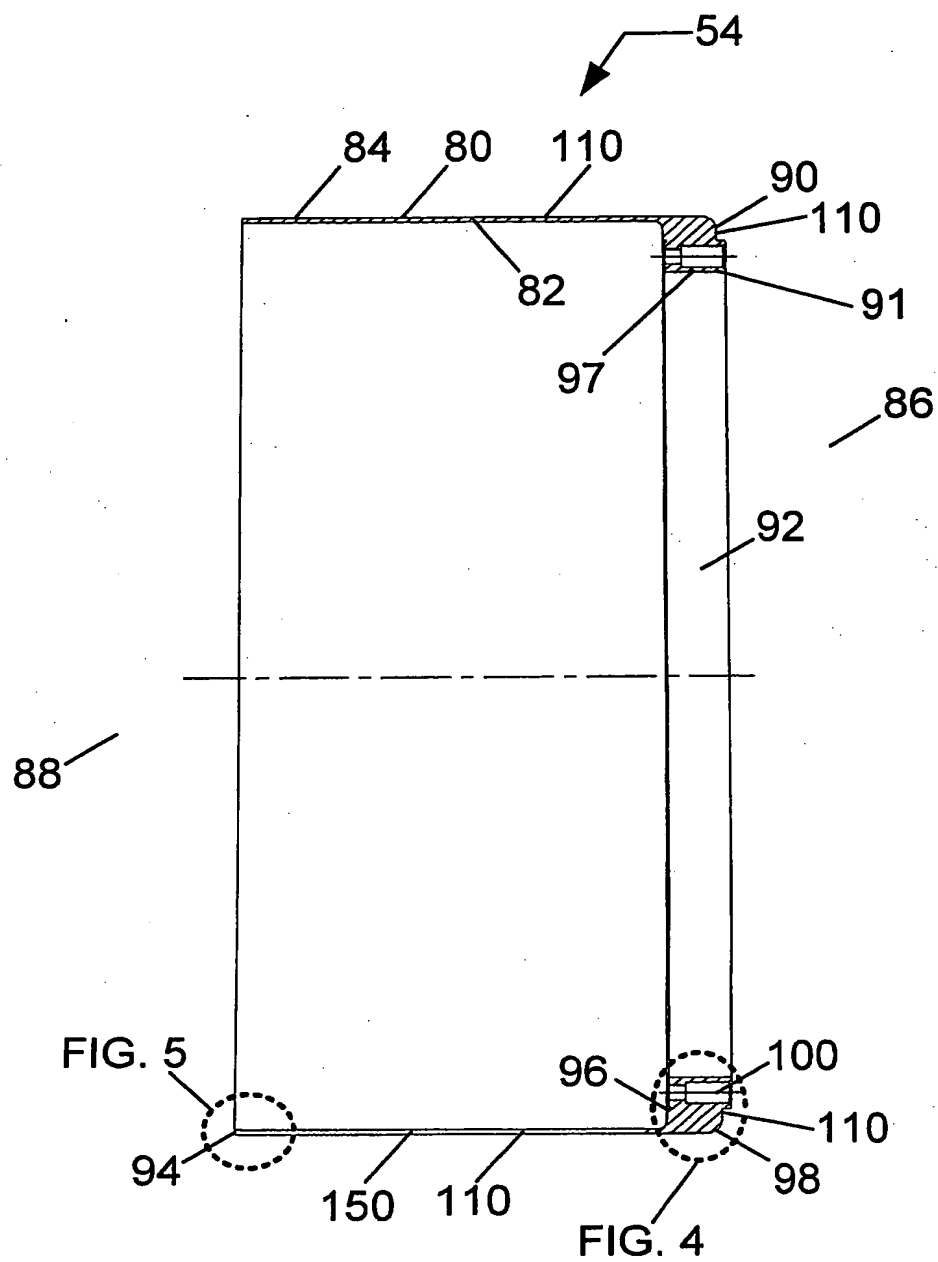


FIG. 2.

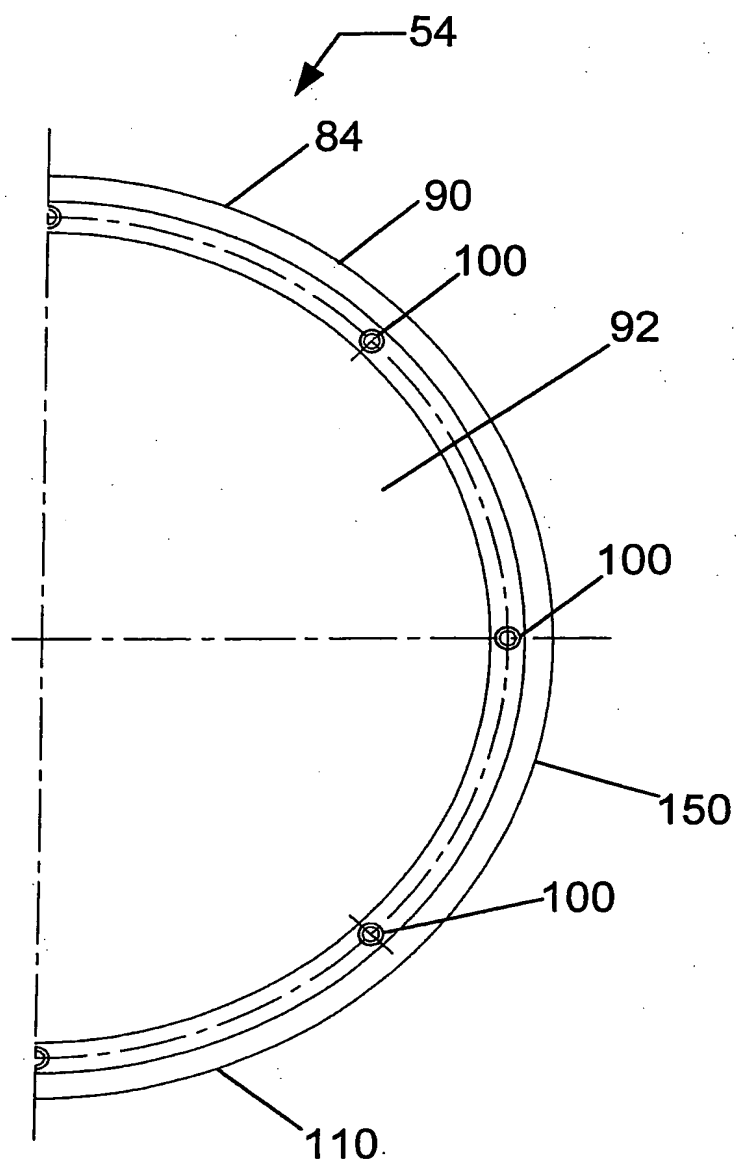


FIG. 3.

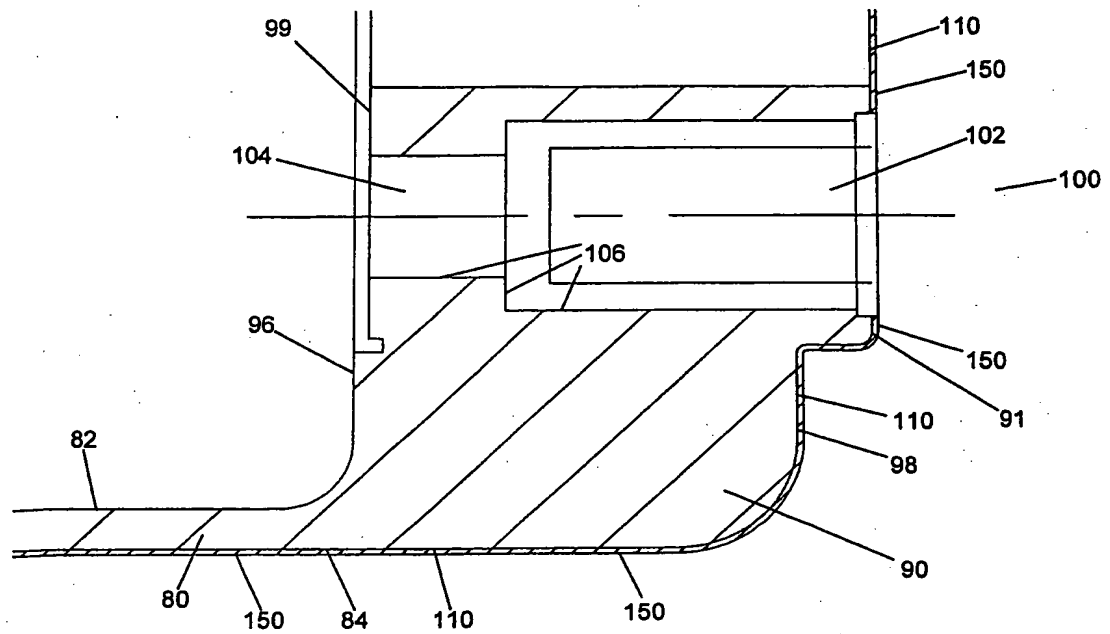


FIG. 4.

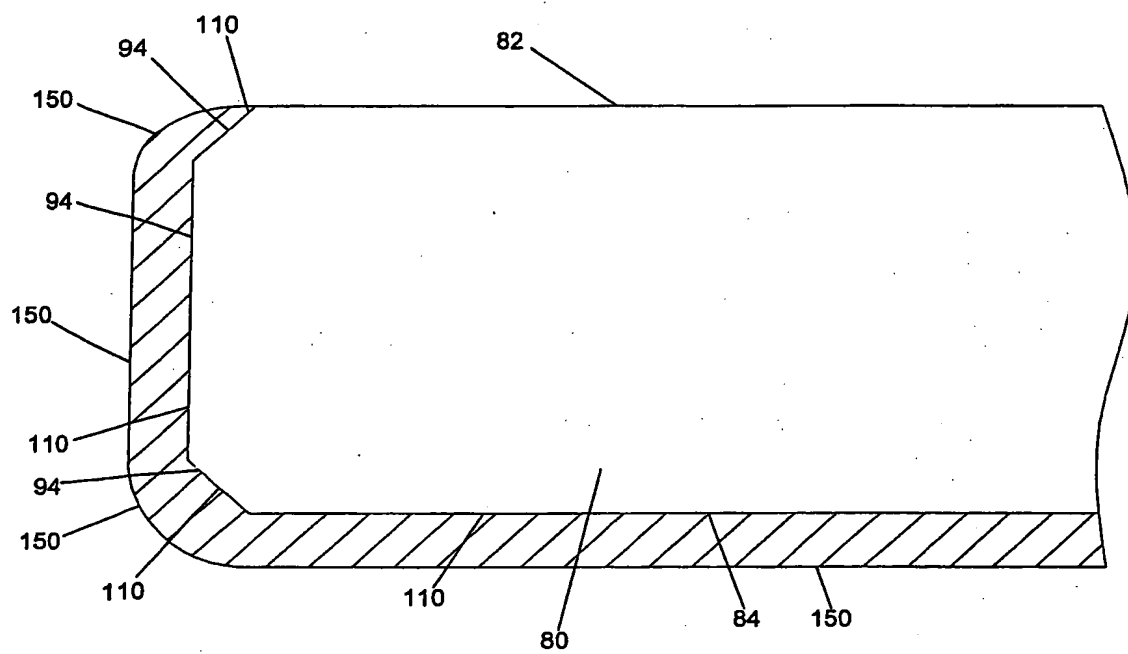


FIG. 5.

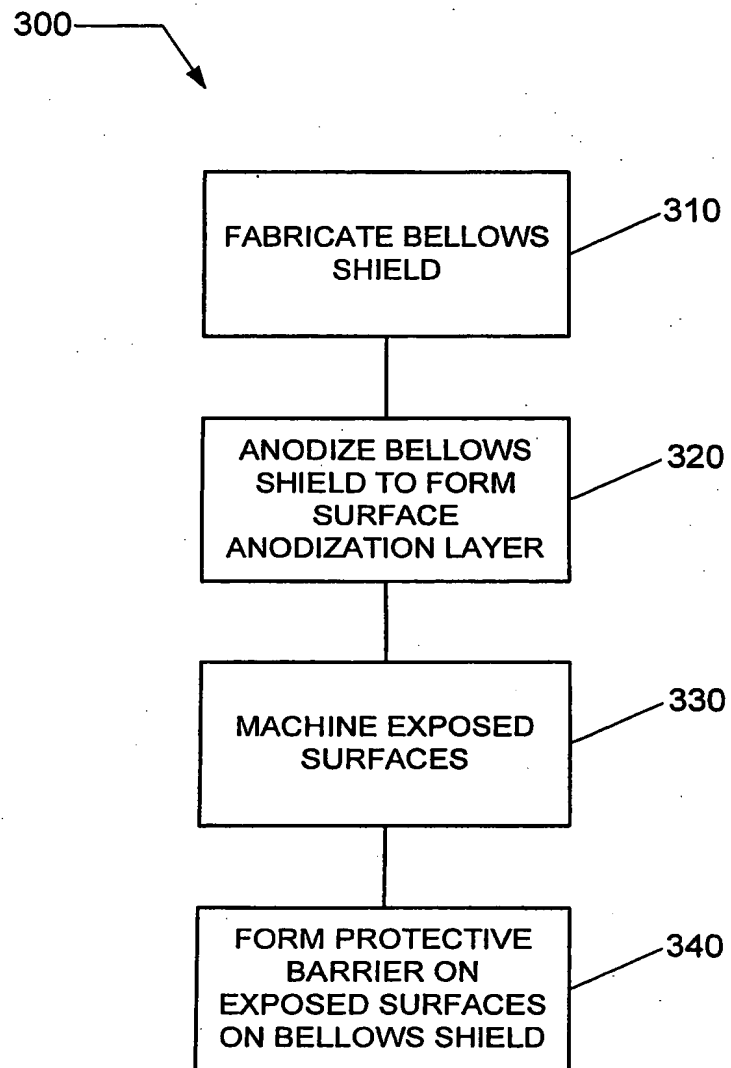


FIG. 6.

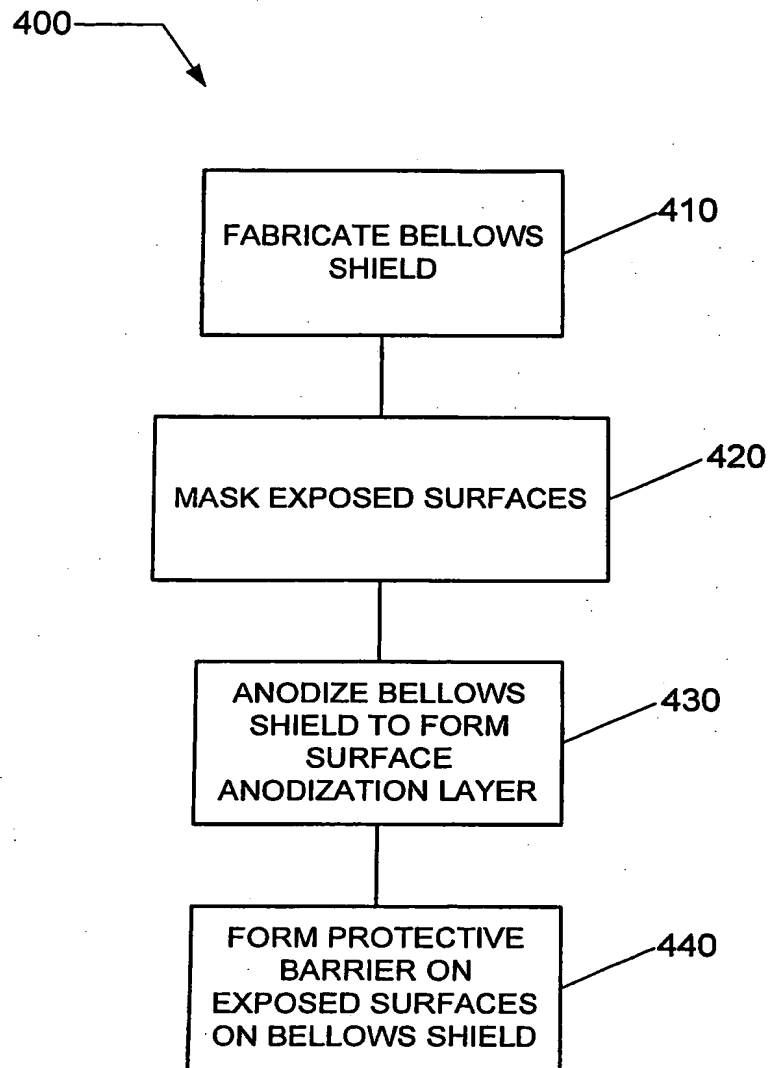


FIG. 7.

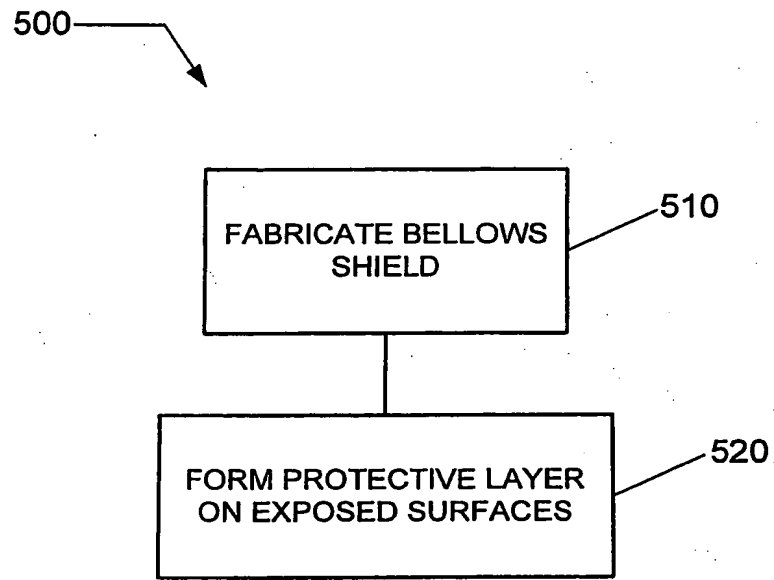


FIG. 8.